Weed Management on the Abundance of Insect Natural Enemies in a Cabbage Field

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Abstract: The study was conducted to determine the effect of weed management level on the abundance of insect natural enemies in cabbage fields. Two levels of weed management were applied in the field, namely with and without herbicide application in two growers' cabbage fields in Malino, South Sulawesi, Indonesia. Results demonstrated that insect natural enemies were more abundant in the field without herbicide application than those in the field with herbicide application. Five species of predatory insect species were collected from both fields, anmely *Solenopsis* sp., *Ophionea* sp., *Euborellia* sp., *Cicindella* sp., and *Paederus fuscipes*. The herbicide and its surroundings were kept weed-free during the growing season. Four most abundant weed species were found in the field without herbicide treatment including *Nasturtium indicum* (Brassicaceae), *Galinsoga parviflora* (Asteraceae), *Ageratum conyzoides* (Asteraceae) and *Cleome rutidospema* (Capparidaceae).

Keywords: Cabbage; refuges; insect natural enemies; weeds

1. Introduction

Cabbage (*Brassica oleracea* var. *capitata*) is one of the most popular vegetables that are cultivated in many highland areas in Indonesia. Cabbage can be consumed either in raw salad or cooked vegetable. Fresh cabbage contains vitamins A, C, carbohydrates, proteins, fat, fiber, phosphorus, iron, and potassium (Soufbauf *et al.*, 2010). Cabbage production has to be increased to fulfill the needs of the growing population. However, this effort is faced with many constraints, including limited availability of healthy seeds and insect pest threats. The diamond back moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) is one the major limiting factors of cabbage cultivation. This insect is considered to be the most damaging pest of crucifers around the world and control costs are estimated to reach US $1 billion annually (Soufbauf *et al.*, 2010).

Most cabbage growers rely heavily on insecticide use to control the diamondback moth. More than 90% of vegetable growers in Malino overuse synthetic insecticides with

dosage and application frequency far above the technical recommendations (Ngatimin, 2009). This practice is very risky because it can cause pest resistance to the insecticide, adverse effects on natural enemies and other non-target organisms, and environmental pollution. In addition, insecticide application cost can easily constitute 50% of the total cabbage production cost.

Previous studies conducted by many workers have shown that cultural practices affect natural enemies of pest insects. Natural enemy abundance can be boosted through noncrop habitat manipulation (Andow 1991; Landis *et al,*. 2005). Weeds usually grow on the edge of a cabbage field. These plants can act as refugia and provide alternative host, nectar, pollen, and honey dew produced by aphids for natural enemies of insect pests. The refugia plants can be used to maintain the presence of pests in low population outside of the growing season to conserve insect natural enemies within or around the field (Barberi *et al.*, 2010). The purpose of this study was to determine the effect of weed management level on the presence and abundance of insect natural enemies, especially predatory insects in cabbage agrosystem.

2. Materials and Methods

2.1 Description of Study Site

The study was conducted in two cabbage growers' fields in Malino, Gowa Regency, South Sulawesi, Indonesia, from October to December 2010. The field trial site was located about 1,100 m above sea level, with an average rainfall rate of 2,900 mm per year and relative humidity and temperature ranging from 88-90% and 18-25^{o}C, respectively, during the course of the study.

2.2 Cabbage Plantation

Two fields, about 300 m apart to prevent natural enemy movement between the fields, were used in this study. One of the fields was kept free of weeds throughout the planting season by weekly applying herbicide; and the other one was left without any weed control measures to allow the weeds to grow freely. Each field consisted of nine plots (3 x 5 m). Cabbage seedlings (cv. KK-Cross) were transplanted to both fields in early October 2010 with a planting space of 25 x 25 cm. To allow the natural enemy populations to grow, no insecticide was applied in both sites during the planting season.

2.3 Weed Identification

From each plot of the field without herbicide application, five weed plants were sampled, following a diagonal pattern. The plants were covered with a plastic sheath then removed for identification in the laboratory. Identification was based on weed description guides by Everaarst (1981) and Soerjani *et al.* (1987).

2.4 Insect Collection

Natural enemies of insects were collected from cabbage plants in both experiment fields (with and without herbicide application), using a battery-powered vacuum pump. Five plants were sampled following diagonal pattern in each plot. The collection of insect natural enemies began 14 days after transplanting until harvest with an interval of seven days. All insect natural enemies present on the plant samples

were sucked into vacuum pumps, placed into plastic bottles containing 70% alcohol, and then brought back to the laboratory for identification. Identification was performed under a dissecting microscope (40 - 100 X) and was based on morphological characteristics of the natural enemies as described by Kalshoven (1981) and CSIRO (1991).

3. Results and Discussion

3.1 Natural Enemy Species in Cabbage Fields

Five species of insect natural enemy were collected from cabbage fields through weekly sampling using battery-powered suction vacuum. Average number of insect natural enemies per plant collected throughout the growing season is presented in Table 1.

Table 1. Average number of insect natural enemies per plant during the growing season, 2010

Insect Natural Enemies		Number of Insect per Plant	
Species	Family	Field with Weeds	Field without Weeds
Solenopsis sp	Formicidae	81	12
Ophionea sp.	Carabidae	34	10
Euborellia sp.	Dermaptera	22	2
Cicindella sp.	Cicindellidae	17	5
Paederus fuscipes	Staphylinidae	13	2

In general, the numbers of natural enemy individuals found in the field without herbicide application were higher than those found in the field with herbicide application. In both fields, the same species of natural enemy were found with similar relative abundance. The most abundant species was *Solenopsis* sp. (Hymenoptera: Formici dae), followed by *Euborellia* sp. (Coleoptera: Carabidae); *Ophionea* sp. (Dermaptera: Anisolabididae), *Cicindella* sp. (Coleptera: Cicindellidae), and *Paederus fuscipes* (Coleoptera: Staphylinidae).

3.2 Weed Species in Cabbage Field

Field applied with herbicide was successfully kept free of weeds throughout the growing season. On the other hand, the field that was intentionally unapplied with herbicide had many different species of weeds. Among the weeds, there were four most abundant species found in the field (Table 2).

Table 2**.** Weed species found in the cabbage field without herbicide application

Species	Family
Nasturtium (*Rorippa*) *indicum* L.	Brassicaceae
Galinsoga parviflora Cav.	Asteraceae
Ageratum conyzoides L.	Asteraceae
Cleome rutidosperma DC	Capparaceae

3.3 Populations of Natural Enemies

The mean number of natural enemy per plant in the field without herbicide application were higher than those in the field with herbicide application throughout the growing season (Figure 1).

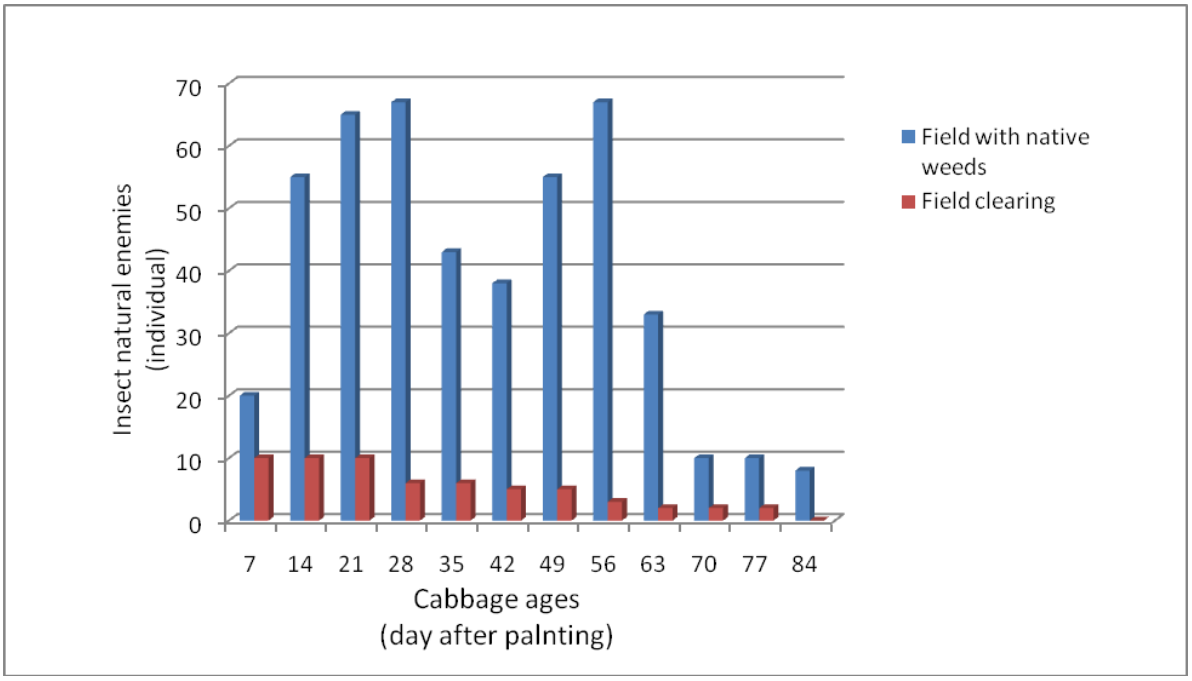

Figure 1. Average number of natural enemy individuals in the cabbage field applied and non-applied with herbicide.

In the field without herbicide use, the number of natural enemy individuals was low in the early season, then increased and reached its first peak on 28 days after planting. In the next two weeks, the number of natural enemy individuals decreased, and then increased to the second peak on 56 days after planting. After, the number steadily decreased towards the end of the season. While the number of natural enemy individuals in the field with herbicide application was lower throughout the growing season. About 10 individuals of natural enemy per plant were collected for the first three weeks of the season and then decreased towards the end of the season.

Five same species of natural enemies were collected from both the experiment fields, with and without use of herbicide, namely *Solenopsis* sp. (Hymenoptera: Formicidae), *Euborellia* sp. (Coleoptera: Carabidae); *Ophionea* sp. (Dermaptera: Anisolabididae), *Cicindella* sp. (Coleptera: Cicindellidae), and *Paederus fuscipes* (Coleoptera: Staphylinidae). Fire ant or scientifically known as *Solenopsi* sp was the most abundant natural enemy in both types of cabbage fields. This insect is common in agricultural fields and acts as predator of small invertebrates such as insects and spiders, centipedes and millipedes, earthworms, and other similarly sized prey (USDA, 1993). The adults are attracted to sugary substances, including honey dew excreted by aphid or whitefly on plant surface and nectar of flower. Other natural enemies are soil-dwelling insects but their adults also feed on plant nectar and pollens.

Four species of weed that were most abundantly found in the field without herbicide application were *N. indicum*

(Brassicaceae), *G. parviflora* (Asteraceae), *A. conyzoides* (Asteraceae), and *C. rutidosperma* (Capparaceae). All species are perennial and produce flowers. The weeds are present throughout the year in the field they can provide shelter, food resources, and alternative prey for natural enemies, especially during the time when no crop hosts are available in the field (Wilkinson and Landis, 2005). In addition, insect natural enemies, including ants use plant parts such as stems, bark and root surface as a shelter from extreme environmental condition (Kumschick *et al.*, 2009). This is probably the main reason why the natural enemies were more abundant in the field where weeds are intentionally allowed to grow compared to field where herbicide was applied.

Our results suggested that weed management can be used as an integral part of integrated pest management implemented in cabbage agricultural system. Weeds have been used to increase the vegetation diversity which in turn helps to enhance the natural enemy population (Altieri and Whitcomb, 2004). Weed population in a crop can be manipulated in such a way that non-crop vegetation can effectively function as source of natural enemies but without causing adverse effects on the main crop production. For example, weeds are kept as strip plant between crop rows or allowed to grow on the boundaries of the field.

5. Conclusion

There is a diversification of weed species abundance in the field without herbicide use leading to a successfully enhanced number of natural enemies. Four species of weeds were found dominant in the cabbage field, namely *Nasturtium indicum* (Brassicaceae), *Galinsoga parviflora* (Asteraceae), *Ageratum conyzoides* (Asteraceae) and *Cleome rutidospema* (Capparidaceae). This perennial non-crop vegetation produces flowers which can become the source of natural enemies present in the fields, including *Solenopsis* sp. (Hymenoptera: Formicidae), *Euborellia* sp. (Coleoptera: Carabidae), *Ophionea* sp. (Dermaptera), *Cicindella* sp. (Coleptera: Cicindellidae), and *Paederus fuscipes* (Coleoptera: Staphylinidae). Further studies should be conducted to determine how those weeds help to enhance the natural enemy population and how to effectively use the weeds in habitat manipulation to suppress insect pest population in the cabbage plantation.

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